Overview

Executive Summary

Crew behavioral health and performance is affected by missions in isolated, confined and extreme (ICE) environments. Future exploration missions will involve humans moving further away from low Earth orbit (LEO) with longer mission durations and will have a greater risk for behavioral health and performance decrements. Ensuring crew behavioral health over the long term is essential.

The risk to behavioral health can be conceptualized as a continuum. On one end is the possibility of adverse cognitive and behavioral conditions arising as a result of factors associated with human space exploration; on the other end, a mental disorder can develop if adverse cognitive or behavioral conditions are not detected or mitigated. NASA defines an adverse behavioral condition as any decrement in mood, cognition, morale or interpersonal interaction that adversely affects operational readiness or performance.

Behavioral health standards optimize the health, well-being and productivity of crewmembers and reduce the risk of behavioral and psychiatric conditions before, during and after missions. Efforts to mitigate loss of behavioral health have included pharmacologic and physical countermeasures, training, and adaptation support.

Standards Overview

4.2.5 Fitness-for-Duty Behavioral Health and Cognition Standard

4.2.5.1 Pre-flight, in-flight, and post-flight crew behavioral health and crewmember cognitive state shall be within clinically accepted values as judged by behavioral health evaluation.

4.2.5.2 End-of-mission assessment and treatment for crewmember cognitive state shall include cognitive assessment, monitoring and, as needed, transitioning the crewmember back to pre-flight values.

4.2.5.3 End-of-mission assessment and treatment for behavioral health of the crewmember shall include behavioral health and psychosocial assessment, monitoring and, as needed, transitioning the crewmember back into terrestrial work, family, and society.

4.2.5.4 The planned number of hours for completion of critical tasks and events, workday, and planned sleep period shall have established limits to assure continued crew health and safety.

4.4.3.5.3 Behavioral Health and Performance

a. Provisions shall be made to implement appropriate psychological support programs for the crew, key ground personnel, and crew families throughout the mission.

b. These provisions shall be detailed in the Program MORD. These provisions may include the following:

(1) Capability to monitor and assess psychological status, including Private Psychological Conferences (PPCs) with two-way video and/or voice communication scheduled at least bi-weekly for each crewmember.

(2) Private Family Conferences (PFCs) with two-way video and/or voice communication scheduled at least weekly for each crewmember.

(3) Crisis intervention as needed.

(4) Capabilities for crew relaxation, recreation, entertainment, news services, and social communication and behavioral adaptation.

4.4.4.4 Psychological Function

Provisions shall be made to implement appropriate psychological support programs as needed for the crew, key ground personnel, and the crew families following space flight.

These provisions may include post-flight behavioral health and cognitive assessments, monitoring, and psychological support to transition the crewmember back into work and family.

Background

Behavioral Health in the space environment

Behavioral health is the scientific study of the emotions, behaviors and biology relating to a person's mental well-being, their ability to function in every day life , their concept of self and how they interact with others.

Common behavioral health conditions or concerns in the spaceflight environment may include stress, depression, anxiety, relationship problems and grief. The condition can be temporary resolving with time and/or intervention or can develop to a psychiatric disorder .

In the space environment , "Behavioral health" is the preferred term to "mental health."

Space flight occurs in an extreme environment that has unique stressors. The assessment of predictive and contributing factors related to behavioral health can help prevent the onset of distress.

Behavioral health among space flight crew is affected by internal and external factors:

- Internal: personality (including how it relates to adjustment), resiliency (hardiness), physiological changes that occur when adapting to microgravity and isolation, and emotional reactions (especially negative emotions).

- External: radiation exposure, habitability and environmental design, job design (autonomy and meaningful work), monotony and boredom, daily hassles and major life events, cultural factors, ground support/mission support, family and social support, world events, and lighting and sleep.

Reference Data

Factors that affect crewmembers behavioral health

Exposure Sources

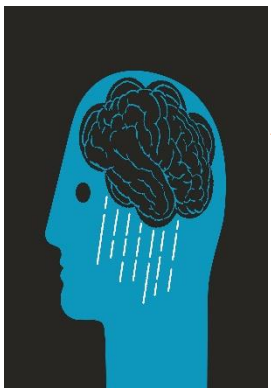
- Carbon dioxide
- Celestial dust
- Toxic
- Sunlight
- Radiation

Isolation

- Cognitive, behavioral, psychiatric disorders
- Cooperation, coordination, psychosocial adaptation
- Inadequate cooperation and communication within a team

Work

- Sleep loss
- Circadian desynchronization
- High / low Work load



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Altered body function

- Immune response
- Hypobaric hypoxia
- Decompression
- Renal stone
- Bone fracture
- Host-microorganism interactions
- Urinary retention
- Orthostatic intolerance
- Cardiac rhythm
- Back pain

Preparedness

- Food and nutrition
- Inflight medical conditions
- Medication

Reduced capacities

- Hearing loss
- Intracranial hypertension/vision alteration
- Vestibular/sensorimotor alteration
- Muscle mass, strength, endurance
- Aerobic capacity

Injury sources

- Dynamic loads
- EVA
- Electrical shock

*Primary factors that affect crewmembers behavioral health

Reference Data

Team effects on Performance and behavioral health

- A crew member's poor adaptation to space stressors has resulted in a number of performance-related effects that could compromise a crew's ability to function, especially under abnormal or emergency conditions (Harrison,2001; Shepanek, 2005).
- "There is considerable anecdotal and behavioral evidence that many crewmembers have experienced psychological and interpersonal difficulties arising from the myriad stressors inherent in space missions, especially those involving longer durations" (Shayler, 2000, as cited in Kanas, 2009).
- Team Cohesion has a moderate to Strong Relationship with Performance when Teams Live and Work Together.
- Teams are critically important for enhancing resilience in high-risk operations. Teams adapt as necessary to protect the group from negative effects of stressors that crewmembers encounter together.
- Soyuz 21 reportedly was ended prematurely due to unspecified "interpersonal issues" with the crew.

Reported Behavioral Health Issues during Spaceflight

- Soyuz T10-Salyut 7 (1984): Crew reported possible hallucinations to mission control.
- Soyuz T14-Salyut 7 (1985): Depression may have contributed to evacuation and early termination of mission.
- 2 of 7 (29%) of NASA Shuttle-Mir astronauts reported depressive symptoms. (Human Research Evidence Report, April 11, 2016)
- A STS Payload specialist became despondent when their experiment failed. Crew reported concerns about the potential for dangerous behavior including opening a hatch. As a result, the STS hatches were fitted with locks.
- Delayed notification to a Russian crewmember of a family member's death led to acute social withdrawal, depression and isolation.

Application Notes

Behavioral Operational Aspect：

The following is an outline of the mitigation strategies that are currently utilized to prevent decrements in behavioral health and performance of the crew during a space flight mission. It should be noted current behavioral health support is provided across the three stages of space flight: before the mission (preparation and training), during the mission (when the crew is in space and receiving support), and after the mission is complete (repatriation and adaptation back to terrestrial life).

These behavioral health support services fall within six broad categories: Selection, training, in-flight psychological and neurobehavioral support, in-flight psychological and neurobehavioral monitoring, family psychological support, and repatriation

1. **Selection:**
   Selection :Behavioral Health and Performance (BHP) Operations provides clinical and suitability evaluations of astronauts applicants and participates throughout selection process.
   Composition**:** Although BHP Operations does not currently facilitate composition assignments for crew flight selections, composition strategies to address technical and non-technical compatibility of the crew will be an integral part of the pre-mission process for future missions.

2. **Training**
   Provides needed training to ensure effective adaptation and performance both at individual and team level. Topics include but are not limited to managing stress, dealing with cultural differences, working as an effective team, small group living , and optimizing sleep and circadian adaptation strategies, etc. This also includes training for crewmembers families.

3. **In-Flight Psychological and Neurobehavioral Support:**
   Private psychological conferences (PPCs) are currently provided; additional psychological support include crew care packages, crew support events, e.g., talk with movie star during mission, and other support services, e.g., movies, books, magazines, favorite TV shows.

Individualized countermeasures for pre-flight and in-flight operations include scheduling recommendations that take into account task load, sleep history, and operation constraints; sleep education and training; and appropriately timed light-dark exposure. When needed, interventions such as cognitive behavioral therapy and pharmaceutical countermeasures are utilized.
For missions beyond 6 months and/or beyond LEO, individualized countermeasures should be provided. The level and type of countermeasure support should match the requirements of the mission (e.g. privacy, private communication with loved ones, window access, periodic access to fresh foods).

Application Notes

Behavioral Operational Aspect :

4. In-Flight Psychological and Neurobehavioral Monitoring:

The development of baselines established from behavioral health and cognitive assessment tools are critical to the development of operating (performance) and morbidity (medical) ranges.

Cognitive testing is a medical requirement and is currently fulfilled by the monthly administration of the Spaceflight Cognitive Assessment Tool for Windows (**WinSCAT).** A preflight baseline is obtained for each astronaut. A monthly in-flight test allows a comparison to each astronaut's baseline. A traumatic injury or illness on orbit would dictate additional testing and assessment.

For missions beyond 6 months and/or beyond LEO, minimally obtrusive measures that objectively evaluate psychological and behavioral states and integrate the information within the context of each mission, e.g., CO2, sleep quantity/quality, work/rest schedule, should be provided.

5. Family Psychological Support:

Current program includes support for crewmember's families; examples of support include Private Family Conferences (PFCs).

For missions beyond 6 months and/or beyond LEO, additional resources to support families, significant others, and friends and to facilitate crew-ground communication, should be provided.

6. Repatriation:

Repatriation briefings are conducted pre-flight and normally 6 weeks before landing with the astronauts and their family members. Additional behavioral support is provided on as- needed basis to facilitate the repatriation and reintegration of the astronauts with their family and work lives.

Reference Documents

Evidence Report: Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders, April 2016 Behavioral Health and Performance
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Basner, M., Dinges, D. F., Mollicone, D. J., Savelev, I., Ecker, A. J., Di Antonio, A., et al. (2014). Psychological and Behavioral Changes during Confinement in a 520-Day Simulated Interplanetary Mission to Mars. PLoS ONE, 9(3), e93298.

Application Notes

Design Applications

Habitat Design Guidance for Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Lack of Personal Space / Lack of Private Space	• Provide individual, separate sleeping/personal quarters w/auditory isolation and physical separation (if possible) for each crew member • Separation of private spaces from spaces allocated for common, social areas and congested translation paths is preferred • Visual separation of private spaces from each other to allow for perception of increased privacy **Volume Accommodation [V2 7039]; Sleep Accommodation [V2 7070]; Private Quarters [V2 7071]; Behavioral Health Privacy [V2 7071] ; Volume Allocation [V2 8001], Volume for Crewmember Accommodation [V2 8002] ,Volume for Mission Accommodation [V2 8003];Functional Arrangement [V2 8005]; Function Arrangement [V2 8005]**
Lack of sleep	• Provide restraints to secure blankets and maintain positioning, with a range from knees-to-chest to full body stature. • Provide individual control of the sleep environment in order to ensure adequate sleep and maintain well-being during missions. • Environmental factors such as noise, temperature, vibration, and light inhibit sleep and affect well-being in space. • Examples of sleep accommodations include clothing, bedding, ear plugs, light blockers, eye masks, etc. **Sleep Accommodation [V2 7070];Continuous Noise Limits [V2 6078];Crew Sleep Continuous Noise Limits [V2 6079]; Intermittent Noise Limits [V2 6080];Annoyance Noise Limits for Crew Sleep [V2 6082]; Impulse Noise Limit [V2 6083];Narrow-Band Noise Limits [V2 6084]; Vibration Exposure Limits during Sleep [V2 6092]; Hearing protection [V2 9057]; Light blocking [V2 8049]; Circadian Entrainment [V2 8055]**
Long periods of low workload / bursts of high workload to emergency and off-nominal conditions	• The user must be able to cognitively process all information sources and physically execute all action within the time required. **Nominal Cognitive Workload [V2 5007]; Off-Nominal Cognitive Workload V2 5008 ;Usability Acceptance Criteria [V2 10001]; Crew Interface Effectiveness [V2 10002];Crew Interface Efficiency [V2 10003];Use of Cues [V2 10015]; Nomenclature Consistency [V2 7061]; System Health and Status [V2 10017];System Feedback [V2 10022]; Illumination Levels [V2 8051]**

Application Notes

Design Applications

This section focuses on long-duration spaceflight considerations (exceed 30 days)

Habitat Design Guidance for Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Lack of Privacy of Waste & Hygiene Compartment	• Dedicated, private area for waste and hygiene with hygiene areas away from dining area and medical station • Separation of Waste & Hygiene Compartment area from translation areas . **Personal Hygiene Capability [V2 7016]; Body Cleansing privacy [V2 7017];Body Waste Management Privacy [V2 7022] ; Body Waste Management System Location [V2 7021]; Private Body Inspection Accommodation [V2 7028]**
Lack of Meaningful Work/Activity	• Provide individual development plans for each person's work goals, progress, and achievements. • Allocation of space and resources to accommodate each individual's work and activities (i.e., science, laboratory equipment, electronic curriculum, etc.). **Cognitive Capabilities [V2 5004]; Time and Performance [V2 5005]; Situational Awareness [V2 5006]; Cognitive Workload [V2 5007]; Nominal Cognitive Workload [V2 5007] ; Off-Nominal Cognitive Workload [V2 5008];4.2.5 Fitness for duty behavioral health and cognition standard V1 4.2.5.4**
Sense of Poorly Placed Stowage	• Ensure stowage types are near designated areas (i.e., food near dining) Ensure that not all materials are stowed in one place. **Personal Stowage[V2 7051] ; Stowage Provisions [V2 7050];Food Preparation[V2 7008];**
Lack of Individual Controls Over Temperature, Ventilation , Lighting, Humidity or Noise	• Place individual controls and distribution vents in crew quarters and at workstations • Place individual controls and distribution vents in crew quarters and at workstations **Relative Humidity [V2 6010] ;Comfort Zone [V2 6012], Temperature Range [V2 6013], Atmospheric Control [V2 6017], Atmospheric Monitoring and Alerting [V2 6022]; Hazardous Noise Limits for All Phases Except Launch, Entry, and Abort [V2 6077];Light blocking[v2 8049];Lighting Controls [V2 8056]**

Application Notes

Design Applications

This section focuses on long-duration spaceflight considerations (exceed 30 days)

Habitat Design Guidance for Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Lack of Stimulation/Sensory Variability	• Windows (Provide visual stimulation of high quality close to Earth, but limited utility on long-duration transit missions) • Virtual Windows - Camera with projections of space, video of terrestrial footage, telescope, "Holodeck" or other virtually immersive environment • Increased spatial vista within habitat Lighting, colors, and other visual countermeasures to increase sensory stimulation • Greenhouse or other introduction of plants and natural elements for tactile, visual, gustatory, olfactory • Different surfaces in the interior to maintain tactile senses • Provision of musical instruments and music selection to counteract auditory • Enhance exercise system to include virtual experience **Window Provisioning [V2 8043]**
Social Deprivation/Lack of Common Areas	• A common area for recreation, large enough to accommodate all crewmembers at the same time • Include 'television' (or equivalent) for crew to watch movies together (movies in the form of data can be transmitted from Earth to also provide sensory stimulation) • A common area for dining, large enough to accommodate all crewmembers dining at the same time. This can be the same as the common area for recreation (converted). Space required for food preparation **Physiological Countermeasures Capability [V2 7038];Food Acceptability [V2 7002]; Food Preparation[V2 7008]; Dining Accommodations [V2 7012] Recreational Capabilities V2 7084]**

Application Notes

Design Applications

This section focuses on long-duration spaceflight considerations (exceed 30 days)

Habitat Design Guidance for Various Psychological Stressors

Psychological Stressor Category	Habitat Design Guidance
Limited Communication with Home	• Communication system should be provided in each private quarter • System that facilitates voice and text should be provided • Private communication with family • Private space with pictures of family members **Communication System Design [V210083];Communication Capability [V2 10084];Communication Speech Levels [V2 10085] ;Communication Operational Parameters [V2 10086]; Communication Environmental Parameters [V2 10087] ;Communication Controls and Procedures [V2 10088] ;Communication Transmitter and Receiver Configuration [V2 10089]; Audio Communications Quality [V2 10090];Speech Intelligibility [V2 10091];Private Audio Communication [V2 10093]; Video Communication Visual Quality [V2 10094]**
Crew Composition	• Characteristics of the crew (team size, gender makeup, job roles, and cultural backgrounds), which are established prior to the mission should be considered when defining the habitat requirements. **Data Sets [V2 4001] ;Population Definition [V2 4003]**
Lack of Hygiene Separation	• Provide separation between clean areas (medical treatment, food prep, crew quarters, etc.) and dirty areas (hygiene, dusty areas, etc.) • Provide olfactory or other partitions to prevent contamination of clean areas. This can include closed, separately ventilated areas. **Body Waste Management Privacy [V2 7022]**
Lack of "Backup Plan" /"Rescue Scenario"	• Placement of hatches to allow for alternate escape routes. • Provision of radiation shelter **Automated and Robotic System Provision [V2 10100]; EVA Suit Radiation Monitoring [V2 11010]; Ionizing Radiation Protection Limit [V2 6095]; Crew Radiation Exposure Limits [V2 6097]; Radiation Environments [V2 6098]; Space Weather Monitoring [V2 6099]**